Bowing of GaN Substrates by Hydride Vapor Phase Epitaxy

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Abstract

The bowing of the crack free GaN films with 300 § - thickness, grown on 2 inch diameter (0001) sapphire wafers by HVPE has been investigated. The shapes of as grown and freestanding GaN films were the convex and concave with a little bowing viewed from the Ga surface, respectively. The FWHM of X-ray rocking curve for (0002) diffraction of the freestanding GaN substrate was smaller than that of thick GaN film with sapphire due to the reduction of curvature radius. X-ray measurement also shows that the nitrogen surface of freestanding GaN has the poor crystalline quality compared with Ga surface. It is the origin of bowing of freestanding GaN.

Introduction

Because of the lack of nitride substrates, films of GaN and related nitride compounds have been commonly grown on sapphire substrate. The use of this foreign substrate causes GaN films many problems such as numerous threading dislocations, stress and bowing. It also complicates the processing step such as formation of laser cavity and electrical contact. An alternative approach is the use of freestanding GaN substrate removed from sapphire substrate after heteroepitaxial growth by HVPE to solve the problems mentioned above. Nichia Chemical Co. developed the violet laser diodes (LDs) with an output power of 30 mW and an estimated lifetime of 15,000 h employing freestanding GaN substrate[1]. In this paper, we report on the bowing of the crack free thick GaN films with diameter of 2 inch.

Experiments

The thick GaN films(300 §) without crack were grown on 2 inch diameter (0001) sapphire substrates by HVPE technique. HCl was reacted with liquid Ga to form GaCl gas which was transported to the growth zone kept at 1050 ¡ Éwhere it was reacted with NH_3 resulting in GaN deposition on the sapphire substrate. Nitrogen gas was used as the carrier. The growth rate and V/III ratio were varied between ~50 § /h and 20~35, respectively. After that GaN layer was separated from the sapphire substrate using the UV laser induced lift-off method[2]. The double crystal X-ray diffraction and nanosurf48 were employed to evaluate the bowing of thick GaN films with sapphire and freestanding GaN substrates.

Results

Fig. 1 shows the crack free thick GaN films with sapphire. After laser processing, the size of the freestanding GaN substrates without crack was equal to that of the initial sapphire substrates. It is the largest GaN substrates among those grown on sapphires to our knowledge. Fig. 2 shows that the curvature shape of as grown and freestanding GaN films were the convex and concave with a little bowing viewed from the Ga surface, respectively. The radius of curvature of thick GaN films with sapphire depended on the thickness of GaN films and sapphire. It increased according as the increasing of the thickness of

sapphire substrate. It reversely increased according as the decreasing of the thickness of GaN film. When the thickness of GaN films and sapphire are 300 § -and 430 § ,- respectively, it is 0.54 m. The origin of convex shape of GaN films with sapphire is the difference of the thermal expansion coefficient between GaN and sapphire. Meanwhile the curvature radius of freestanding GaN films with concave shape was 0.93 m. The FWHM of X-ray rocking curve for (0002) diffraction of free standing GaN was smaller than that of thick GaN film with sapphire due to the reduction of curvature radius as shown in Fig. 3. X-ray data also shows that nitrogen surface of freestanding GaN has the poor crystalline quality compared with Ga surface. Because of this reason, although the thick GaN films were separated from sapphire, there remains the strain in freestanding GaN.

Conclusion

The thick GaN films(300 §) without crack were grown on 2 inch diameter (0001) sapphire substrates by HVPE technique. The curvature shapes of as grown and freestanding GaN films were the convex and concave with a little bowing viewed from the Ga surface, respectively. When the thickness of GaN films and sapphire are 300 § - and 430 § ,- respectively, it is 0.54 m. The radius of curvature of freestanding GaN films of thickness 300 § - with concave shape was 0.93 m.

References

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Fig. 1. Crack free thick GaN films grown on sapphire by HVPE

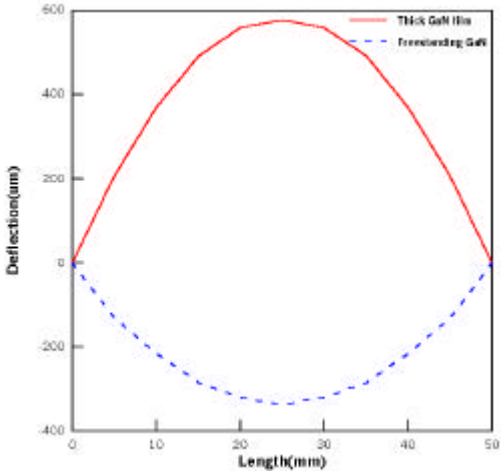

Fig. 2. Bowing of as grown and freestanding GaN films viewed from the Ga surface

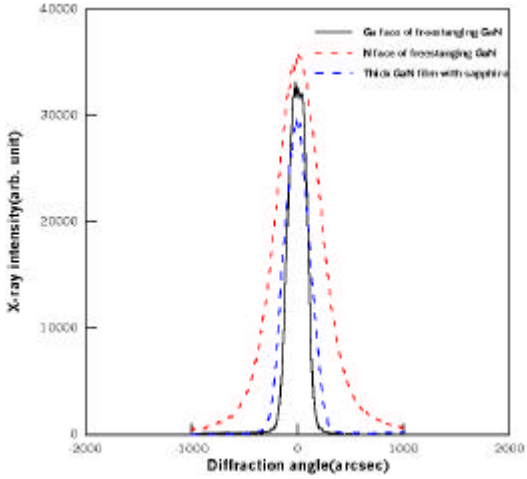

Fig. 3. X-ray rocking curve of as-grown GaN thick films and gallium and nitrogen surface of freestanding GaN